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ABSTRACT

The major aspects of this project are proceeding toward completion. Design criteria, tentative initial site selection, facility layout, and preliminary facility cost estimates have been completed and issued to the project team for review. Design and equipment selection for the pilot trial phase of this program have been completed. Pilot facility modification is expected to continue during the fourth quarter with initial facility shakedown to immediately follow. Processing of bio-solids has been completed, providing material for the pilot testing phase.

The TVA-Colbert facility is making progress in the evaluation of the co-location of this facility on the operation of the power generation facility. Current information indicates that the Colbert facility will be able to meet the steam demand of the Masada facility.

REPORT NO. 00-10734/02

QUARTERLY REPORT FOR THE CONCEPTUAL DESIGN ASSESSMENT FOR THE CO-FIRING OF BIOREFINERY SUPPLIED LIGNIN PROJECT

PROJECT NO. 00-10734
MASADA DOE LIGNIN STUDY

MASADA RESOURCE GROUP, LLC
BIRMINGHAM, AL

DATE: OCTOBER 27, 2000

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1. INTRODUCTION

The development of renewable domestic fuel sources is a desirable goal with positive economic and environmental impacts. Masada Resource Group (MRG) has developed a proprietary process for the conversion of municipal solid waste (MSW) and sewage sludge (SS) into ethanol (CES OxyNol™ Process). One of the byproducts of this process is a solid lignin product. MRG has developed a method for using this MSW-derived lignin as a solid fuel for steam generation. In this joint research project, a conceptual design will be developed that joins a CES OxyNol™ facility with a Tennessee Valley Authority (TVA) coal-fired power plant (the TVA-Colbert facility).

MRG is working with Harris Group Inc. (HGI), TVA, and the National Energy Technology Laboratory (NETL) to develop a conceptual design for the co-firing of bio-refinery-derived lignin fuel in a coal-fired steam boiler. This project will research the dewatering and fuel properties of the CES OxyNol™-derived fuel. The project will evaluate the technological feasibility and cost/benefit analysis of co-locating a CES OxyNol™ facility with the TVA-Colbert facility with the bio-refinery supplying boiler fuel to the Colbert facility and the Colbert facility providing the process steam needed for the CES OxyNol™ process. The co-location has the benefit of providing a low-cost renewable fuel source that can be co-fired with coal. Co-location also reduces the capital and operating costs of the CES OxyNol™ process and provides environmental gains by reducing the impact of coal combustion and providing an environmentally acceptable method for the disposal of solid waste.

This project has been divided into six separate but related tasks to reach the aforementioned goals of the project. Progress has been made on several of the specific tasks in the preparation for the pilot production run. The goal of the pilot run is both to evaluate dewatering options and to generate lignin to be used in the co-fire evaluation at NETL. Design and modifications of the pilot facility at the TVA-PPI laboratory have begun with the development of a process flow, the sizing of key equipment, and the identification of equipment requiring purchase or rental.

The first task is the overall feasibility analysis for the co-location of the Masada facility with a TVA power facility. Task 1 will

- Identify facility design criteria.
- Identify potential facility location and preliminary site layout.
- Evaluate the economic impact associated with co-location.

The second task is the assessment of the impacts on the TVA facility. TVA's Fossil Engineering Organization is performing a preliminary engineering assessment for delivering steam from the TVA Colbert fossil plant to the proposed Masada waste processing facility. The study will identify

- Steam supply connection point in the Colbert plant steam cycle
- Steam pipe routing from the steam cycle connection to the Colbert plant boundary
- Capacity and heat rate impacts on the Colbert plant resulting from the steam supply
- Environmental review of the steam pipe installation
- Capital cost of the steam supply design, materials, and installation
- Operation and maintenance cost impacts on the Colbert plant resulting from the steam supply

This information will be used to develop a price for the steam to be supplied from the Colbert plant to the Masada facility.

Tasks 3 and 4 involve the pilot plant facility design, modification, and shakedown for the production of lignin. Pilot plant design and modification have been progressing during the quarter with the pilot plant operations run tentatively scheduled for November.

Task 5, 6, and 7 are the production of lignin, lignin dewatering, and co-fire testing at the NETL facility. These tasks await the completions of Tasks 3 and 4, which are expected to be completed during the fourth quarter.

2. EXPERIMENTAL

Experimental plans are currently being developed by TVA and HGI to complete this study. TVA has considerable experience in the acid hydrolysis process and its experimental experience will be applied to the lignin production. The lignin dewatering and conditioning will be studied in conjunction with dewatering equipment vendors and with the input of NETL.

Information on the process and dewatering tests that have been conducted by TVA was sent to NETL (Mark Freeman and George Wen). TVA prepared 5-gal samples of unfiltered processed sewage sludge, and hydrolyzate to be shipped to NETL (George Wen) for dewatering tests. Sewage sludge was received from Alfa Laval for processing. Information about the preparation of the samples and analyses was sent to Angela Cooper of NETL for environmental approval. There are no MSDSs on either the processed sewage sludge or the hydrolyzate. Both samples involve use of sulfuric acid during the proprietary processing, and the sewage sludge neutralizes the small amount of acid during processing. TVA historically attaches a sulfuric acid MSDS to samples with a pH below 4 (hydrolyzate), and this procedure was approved by NETL. The 5 gal of unfiltered processed sewage sludge was shipped to NETL on September 20 and the 5 gal of unfiltered hydrolyzate is scheduled for shipment in early October. Information on TVA's pilot plant safety procedures was sent to NETL.

3. RESULTS AND DISCUSSION

3.1 General

A meeting was held at the DOE-NETL facility in Pittsburgh, Pennsylvania to discuss the project and define the roles of team members and NETL's ability and participation. Mark Freeman of NETL provided a tour of the various NETL fuel testing/test burn facilities.

Mark provided some initial constraints and fuel requirements to perform a test burn in the NETL test solid fuel boiler simulator. George Wen provided a tour of the dewatering testing facility and expressed interest in testing the NETL technology for the various separations in the Masada process. George also expressed interest in participation in the pilot studies by using the NETL dewatering technology. Subsequent to this meeting J.G. Broder of TVA-PPI was contacted to provide George with some representative samples from the hydrolysis process for dewatering investigation. These samples were provided to NETL and the dewatering testing and reporting have not yet been completed.

3.2 Engineering Impact Analysis

The preliminary design criteria for the Masada Colbert facility were issued to the team members. The design criteria are based on a WinGEMS mass balance simulation of the proprietary Masada process for a facility suitably sized based on Masada facility capacity. This report contained the necessary design criteria for the TVA Colbert power facility to make the initial investigations into the expected impacts and facility modifications that would be required for this project. TVA power is currently investigating the impacts on the plant steam cycle and power plant operations. The design criteria and basis are included in the proprietary section of the appendix.

A preliminary site for the facility has been identified to the west of the TVA-Colbert power plant in an industrial park development area. Two potential sites within the park have been selected that are nearest to the TVA reservation boundary. This selection of these sites is preliminary for purposes of this study. Final site selection will be predicated on community approval and economic viability. A preliminary site layout on the site nearest to the TVA reservation has been developed including sections for the transportation of steam, condensate, and solid fuel to and from TVA. The preliminary site layout for the Masada facility is included in the proprietary section of the appendix.

Initial capital cost estimates for the Masada facility have been completed based on the configuration associated with the co-location of this facility. This capital cost estimate is included in the proprietary section of the appendix.

3.3 Bench and Pilot Testing

Initial process flow diagrams (PFD) were developed for the pilot test and a preliminary pilot facility mass balance was calculated. The PFD and mass balance summary were provided to TVA-PPI for comments and modification. A preliminary equipment list and an overview of the pilot operation procedures have been completed.

3.4 Pilot Plant Modifications

TVA is working with Harris and Masada to find equipment needed for the upcoming lignin production run. TVA has identified several tanks and pumps that can be used. Several pieces of equipment have been identified that will either require rental or purchase for the completion of this project. The primary equipment not available at TVA includes a suitable vessel for the hydrolysis reaction, a suitable acid pump, a dump tank for mixer effluent, and an industrial mixer for cellulose decrystalization and gel formation. Several vendors have supplied quotes for the hydrolysis reactor and for suitable acid pumps. TVA and Harris have worked together to design two FRP tanks needed for capturing the contents of the mixer and for cooking the hydrolyzate. Both the hydrolysis reactor and dump tank have been specified

and orders have been placed. These vessels are scheduled for delivery at the TVA-PPI pilot facility by October 20, 2000. A suitable acid pump has been ordered for delivery by October 20, 2000. A mixer vendor has been identified and equipment rental terms are under negotiation. Pneumapress Corporation has been identified as the preferred equipment provider for lignin dewatering equipment and it has supplied a quote for equipment rental and operations. TVA will start moving the identified equipment into the pilot plant in October. Drums of sewage sludge supernatant were received from Alfa Laval September 7 for use in the pilot plant production run.

Several pre-processing steps are required to operate the pilot test. These include obtaining, shredding, and sizing MSW feed for the pilot facility and the cooking and dewatering of biosolids to provide both solid fuel and the aforementioned biosolids centrate for use in the process.

RRT has been contacted to supply MSW feed material. RRT is currently in the process of obtaining the feed material as well as supplying feed shredding equipment. Davenport Machine has been identified as the facility that will dry the MSW material and is awaiting MSW feed. Davenport will also perform the feed shredding utilizing a shredder to be provided by RRT.

The procurement and processing of biosolids have been completed. Treatment and dewatering of biosolids were accomplished at Alfa Laval using a proprietary Masada process. The centrate from this process was delivered to TVA on September 7.

During the next quarter we expect that the pilot facility modification and shakedown will be completed and lignin production run will begin. Pilot facility modifications are scheduled to be completed by approximately October 27, 2000. Facility shakedown will begin immediately after the modifications are completed with the lignin production run to follow. Lignin production is anticipated to begin in early November.

3.5 Preliminary Engineering Interface Assessment and Design for TVA Coal-Fired Facility

The Colbert fossil plant consists of five pulverized coal-fired electricity generating units. Units 1 through 4 are identical and have the following characteristics:

- Capacity 200 MW
- Main steam flow 1,287,000 lb/hr
- Main steam pressure 1815 psig
- Main steam temperature 1050°F
- Reheat steam flow 1,122,000 lb/hr
- Reheat steam pressure 402 psig
- Reheat steam temperature 1050°F
- Steam turbine extractions eight at various pressures

Units 1 through 4 began commercial operation in 1955. Unit 5 is a unique, larger capacity (500 MW) unit and was not considered as a steam supply source.

Harris Group Inc. provided TVA the design case steam requirements of the Masada facility. The requirements include the following:

- Steam pressure, psig 150
- Steam quality Saturated
- Base demand, lb/hr 217,420
- Peak demand, lb/hr 229,420

The peak demand is the basis for the TVA engineering assessment.

A location for the Masada facility has been identified adjacent to the western boundary of the Colbert plant reservation. This location is the basis of steam pipeline routing and steam line pressure drop calculations.

There are several locations in the Colbert Unit 1 through 4 steam cycles from which steam could be taken for export to a steam user. The selected location must provide steam of sufficient temperature and pressure so that the steam user's required steam conditions can be maintained throughout the range of Colbert operating conditions. The steam export connection location should be selected so that the negative impacts (capacity, heat rate, and operation and maintenance costs) on the Colbert plant are minimized. Steam connection locations that have been investigated are

- Main steam
- Cold reheat steam
- No. 1 steam turbine extraction
- No. 2 steam turbine extraction

Results to date indicate that main steam is the preferred location from which to export steam for the Masada application. One of the four units can supply the steam requirement even at reduced unit loads. (Although one unit will be able to supply adequate steam, at least two and potentially all four units will be connected to the steam supply in order to assure a reliable steam supply while accommodating planned and forced unit outages.) The other steam export locations considered could not provide steam at sufficient pressure at low load operation to overcome the expected pressure drop in the steam pipeline to the Masada facility. Main steam will be attemperated to desired conditions with water from either the boiler feedwater pump discharge or the condenser hotwell pump discharge. No steam turbine operating constraints would be violated by supplying the required quantity steam from main steam.

Steam cycle analysis thus far indicates that Colbert plant capacity will be reduced by about 29 MW at peak design steam supply requirements when the unit(s) supplying steam are at full load. Net plant heat rate based on the reduced plant generating capacity will be increased by about 1,700 Btu/kW-hr. These impacts may be revised through further analysis.

Two potential steam pipeline routes have been identified from the Colbert powerhouse to the Colbert boundary. The longer route would require 8,400 ft of pipeline (including road and creek crossings and expansion loops) and the shorter route would require 7,400 ft (including road and creek crossings and expansion loops). These lengths may change somewhat should the assumed connection point at the Colbert boundary be relocated. Each pipeline route includes four road crossings and one crossing of Cane Creek.

An environmental review of the two routes will be completed to identify any impacts to sensitive wetlands or archaeological resources before a final route is selected. Additional pipeline will be required from the Colbert boundary to the termination point in the Masada facility. The section of pipe outside the Colbert plant boundary is not within the scope of this task.

4. CONCLUSION

The initial design criteria of the MSW to ethanol facility have been completed along with preliminary site identification and layouts for the processing facility. These items are the first step in evaluating the feasibility of this co-located facility.

Pilot facility design and modification are underway for the production and dewatering of the lignin fuel. Major process equipment identification has been completed and several key unit operations will be accomplished on rental equipment. Equipment not available for rental or at TVA has been ordered and facility modification and shakedown will begin in October.

The study of the interface and resulting impacts on the TVA Colbert facility are underway. The TVA Colbert fossil plant is fully capable of providing a reliable steam supply for the proposed Masada waste processing facility. The preferred supply location in the Colbert steam cycle has been identified as have possible steam pipeline routes to the Colbert boundary. Additional analysis is underway to fully predict the impact of the steam supply on Colbert plant performance and to select a final steam pipeline route.

5. LIST OF ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
HGI	Harris Group Inc.
MRG	Masada Resource Group, LLC
MSW	Municipal Solid Waste
NETL	National Energy Technology Laboratory (also FETC, Federal Energy Technology Center)
PFD	Process Flow Diagram
RRT	RRT Design and Construction, Inc.
SS	Sewage Sludge
TVA	Tennessee Valley Authority
TVA-PPI	TVA Public Power Institute
WWT	Waste Water Treatment

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